Modeling And Forecasting Imported Japanese Parts Content Of US Transplants: An Error Correction And State Space Approach

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MODELLING AND FORECASTING IMPORTED JAPANESE PARTS CONTENT OF US TRANSPLANTS: AN ERROR CORRECTION AND STATE SPACE APPROACH

ABSTRACT

This paper provides a sectoral examination of the impact of trade policies and custom valuation procedures on estimating time varying import content of Japanese transplant automobiles. Using monthly data from 1985 to 1992, we introduce an error correction model (ECM) and a state space VAR model to purify trade data of measurement errors induced by unobserveable prices and customs valuation procedures. Data show that US import of Japanese auto parts are elastic to the fleet of active Japanese automobiles in the U.S., inelastic to transplant production and that disequilibrium adjustments relative to transplant production are corrected in one period. Further, changes in imports are responsive to the cyclical behavior of Big 3 production and the debt burden of automobile consumers. Moreover, we find that productivity trends in the automotive industry are not a significant determinant of imported parts. The model predicts that Japanese manufacturers will shift more production to the US in response to yen appreciation against the dollar. We show that whereas import content decreased following the Fair Trade in Parts Act and the Omnibus Trade and Competitiveness Act of 1988, it increased shortly thereafter and predictions are that it will continue to increase. Therefore the empirical evidence suggests that direct trade policies designed to reduce import content and increase domestic sourcing of auto parts are not effective in the long run.

Keywords: measurement error, error correction, state space forecasts, time varying import content

Journal of Economic Literature Classification Number: C3 C32 and C5 C51 C53 and F40 F47

1. INTRODUCTION

In 1990 the U.S.-Japan Bilateral Automotive Trade Deficit accounted for 65% of the total U.S.-Japan trade deficit and automotive parts comprised approximately 27% of that figure. Thus, the deficit in US-Japan Bilateral Automotive Parts Trade is one of the most urgent contemporary issues facing the economy. This follows from its significance in the overall decline of Big Three market share and massive unemployment due to record financial losses and subsequent plant closings[1]. As a result, current trade policy is aimed at reducing the automotive trade deficit by reducing the import content of Japanese transplants via increased sourcing of US made autoparts, increasing the amount of auto parts exported to Japan or both[2]. To facilitate that process, the U.S. Automotive Parts Advisory Committee (APAC) was created by the Fair Trade in Parts Act of 1988, as part of the Omnibus Trade and Competitiveness Act of 1988, for the purpose of advising the Secretary of Commerce on any and all issues related to increasing sales of US made auto parts to Japan. Moreover, the APAC charter is filed with the Senate Committee on Finance; Senate Committee on Banking, Housing and Urban Affairs; House Committee on Energy and Commerce and House Committee on Ways and Means. Clearly, the automotive parts trade is a major sectoral issue on the agenda of US-Japan Bilateral Trade[3]. In this paper we investigate the effectiveness of current trade policies in mitigating the flow of parts and provide some prognostication based on U.S. customs valuation data.

Many researchers of the US automobile industry investigated the welfare effects of quotas and voluntary export restraints (VER) induced by Japanese automobile exporters (see DeMelo and Tarr(1990, 1991), Morke and Tarr (1984), Dinopolous and Krienin (1988), Feenstra (1988)). Adams, Gagnes and Huang (1991) and Adams (1993) posited the positive welfare effects of

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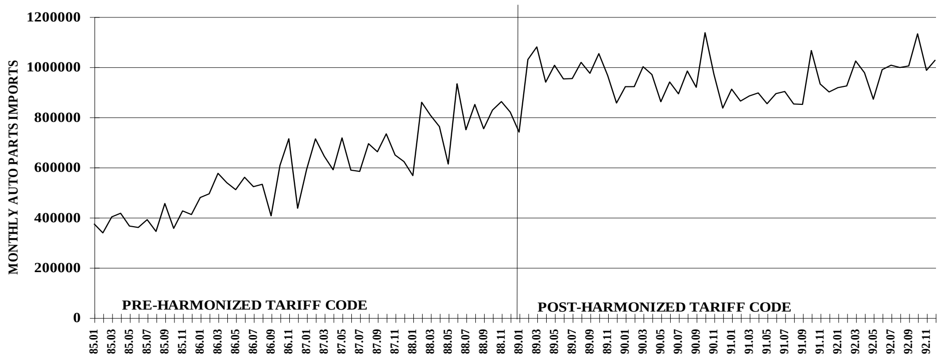
[1] See Manifold (1992), Forrest (1993) and Mc Alinden and Smith (1993).

[2] According to *The AutoParts Report*, in June 17, 1993, Senator Donald W. Riegle (D-Mich) introduced the Fair Trade in Motor Vehicle Parts Act of 1993 (S 1132) to introduce sanctions under section 301 of U.S. trade law against countries that limit access of US autoparts to their markets. Similarly, Senator Max S. Baucus (D-Mont) introduced Bill S 269 to renew provisions in Section 301 (which was part of the 1988 Omnibus Trade Act) to impose sanctions against countries that did not engage in certain trade liberalization practices.

[3] See Manifold (1993) for a more detailed overview of the issues and political implications of this trade.

transplant manufacturer investment on the US. Using a slightly different paradigm, Dixit (1988)

Figure 1. *US Imports of Auto Parts Made in Japan: 1985:1-1992:12*



employed a calibration model to compare the difference between an import tariff on Japanese cars and a production subsidy on US made cars and found that production subsidies or domestic antitrust policies were more effective in increasing US real income, versus an import tariff. Another line of inquiry pursued in the literature investigates pricing to market and yen/dollar pass through effects on the automobile manufacturing sector either directly or indirectly (see Krugman (1987), Clarida (1992b), Marston (1990)). Further, in the strategic management and industrial organization literature emphasis is placed on auto parts suppliers relationship with automobile manufacturers in the context of vertical integration or otherwise (Asanamuma (1985a, 1985b), Cusumano and Takeishi (1992), Richardson (1993)). Recently Cooper and Haltiwanger (1993) examined the impact of retooling/machine replacement in the automotive industry on fluctuations in employment and productivity`.

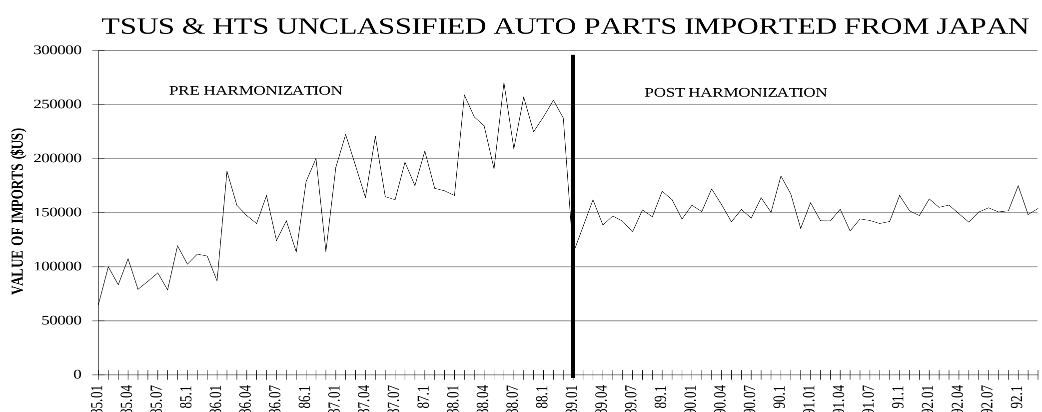
This paper fills a void in the literature by analyzing the effectiveness of trade policy on US-Japan Bilateral Auto Parts Trade. It focuses on the estimation and implication of time varying (dollar) value of imported Japanese parts[4] content in US built transplants (automobiles produced in the US by Japanese subsidiaries). The analysis spans the period before and after implementation of the Fair Trade in Parts Act of 1988 and the Omnibus Trade and Competitiveness Act of 1988. If

[4] This is also known as original equipment manufacturer or OEM in the literature.

trade policy is effective, then one would expect a significant decrease in import content over time otherwise trade policy may be ineffective - at least in the short run.

Modelling US-Japan auto parts trade is not without controversy. For instance, the Japanese Automobile Manufacturers of America (JAMA) posit that most of the parts deficit are due to after market sales and Big Three utilization of Japanese parts in domestic production. However, this assertion conflicts with results from studies conducted by the Office for the Study of Automotive Transportation[5] (OSAT) which show that transplant production is the major source of this deficit. Further, some domestic suppliers are pushing for government sanctions and legal action against Japanese parts imports. They allege that parts dumping and countervailance activities by Japanese manufacturers are injurious to the US auto parts industry and account for a large portion of the

Figure 2: *Residual Classification Error of Auto Parts Imported from Japan*



trade deficit. If these allegations prevail or otherwise permeate domestic political beliefs, then under proposed legislation, they may induce retaliatory action by the US authorities thereby triggering a trade war.

To better gauge the magnitude of US imports of autoparts the US Department of Commerce instituted a harmonized tariff schedule on January 1, 1989, to classify imports and assign them accordingly. This created a shock in the time series data and effectively induced a pre and post

[5] See OSAT-UMTRI Report 91-20

harmonized tariff code regime. Most importantly, the new process revealed the pervasiveness of measurement error in the "old" data. Figure 1 shows the time series plot of US imports of Japanese made auto parts before and after the imposition of a harmonized tariff code. Figure 2 depicts the time series plot of the corresponding residual classification error induced by customs valuation arising from from the Tariff schedule of the United States (TSUS) existing in the pre-harmonization period and the Harmonized Tariff Schedule (HTS) in effect on January 1, 1989. Measurement error is most evident in the pre-harmonization (i.e. before January 1, 1989) period. Some analysts have responded to the measurement error problem by discarding pre 1989 data in favor of post-1989 data. However, this procedure 'throws the baby with the bath water' because it jettisons valid information on US-Japan trade during the pre-1989 period. Moreover, it effectively forces analysts to work with smaller samples (in the post harmonization period) from which policy recommendations are made. The relative inefficiency of small sample bias could adversely affect assessments of the bilateral trade.

This study measures the impact of policy by providing (1) forecasts and robust estimates of time varying imported Japanese parts content in US transplant automobiles, and (2) estimates of the parameters of long run and short run changes in the auto parts trade. In order to attain these goals we present a simple intertemporal model of US-Japan Auto Parts Trade in Section II. The microfoundations of the model provides guidance and motivation in the choice of variables and or instruments used in the empirical analyses that follow. In Section III we present an example of spurrious regression utilizing levels of trade data and identify more stable results from a comparatively parsimonious model. Next we estimate the long run and short run trade offs in the auto parts trade via an error correction model (ECM). In Section IV we introduce a state space vector autoregressive (VAR) model to provide forecasts of key trade variables in order to augment the sample and provide estimates of the impact of policy on time varying import content. The augmented data set was broken into deciles and a series of rolling regressions were used provided to obtain time varying estimates of import content. Section V is the summary and conclusion.

II. A THEORY OF THE AUTO PARTS TRADE

In this section we provide some theoretical motivation for the choice of variables used in the empirical models. Issues affecting the demand for automotive parts are explored. In the manufacturing sector we assume that firms follow the neoclassical paradigm of profit maximization. In the consumer sector we utilize a representative agent approach to automobile consumption.

Demand for Automotive Parts

We posit a two sector model with an automobile manufacturing and automobile purchasing sector in order to investigate the impact of US demand for Japanese transplants on the auto parts trade. In this partial equilibrium setup we assume that the manufacturing sector utilizes labor and auto parts to make automobiles for given amounts of capital. Furthermore, we assume that autoworkers are also the consumers that comprise the auto purchasing sector. A modified two good rational expectations model is employed to analyze consumption of transplant automobiles. In the purchasing sector, automobile consumers seek to maximize their utility from automobile purchases subject to budgetary constraints. The model sheds some light on factors that help to determine the demand for Japanese auto parts.

The Model

In the manufacturing sector we assume that firms are myopic (see Blanchard and Melino (1986) for a more intricate model with forward looking agents) and maximize profits subject to cost constraints. Suppose that automobile manufacturers only use labor L_t and auto parts H_t to manufacture automobiles. Further, assume that capital K_t is fixed in the short run, W_t is wages, Y_t is units of automobiles produced and P_t^h is the price of automobile parts.

Firm's Problem

$$\underset{\{L_t, C_t\}}{Max}\, \pi = P_t^a Y_t - W_t L_t - P_t^h H_t - K_t$$
$$\text{subject to:} \qquad \textbf{[1]}$$
$$Y_t = F(L_t, H_t | K_t)$$

where π is profits.

Let $C_t = C_t^d + C_t^m$, be the total amount of non-transplant automobiles purchased by US consumers where C_t^d is Big 3 production and C_t^m is imports; F_t is the amount of transplant automobiles produced; P_t^c an index of automobile prices in US dollars; P_t^f the price of a transplant; A_t the assets of automobile buyers; ρ the subjective discount rate which we assume to be the real interest rate without loss of generality; r_t is the prevailing market interest rate. In order to identify the derived demand for automotive parts we modify and extend Clarida's (1992) model. Assume that automobile consumers have preferences over sequences of transplant and non-transplant automobiles, and maximize the present value of their utility stream from automobile consumption for some continuous, strictly concave and differentiable utility function $U(C_t, F_t)$, as follows:

Automobile Consumer's Problem

$$\underset{\{C_t, F_t, A_{t+1}\}}{Max} E_t\left[\sum_{t=0}^{T} \beta^t U(C_t, F_t)\right]$$

$$\text{subject to the series of budget constraints:} \qquad \textbf{[2]}$$

$$P_t^f F_t + P_t^c C_t + A_{t+1} = (1 + r_t)A_t + W_t L_t$$

$$A_t \geq 0, F_t \geq 0, C_t \geq 0, \ \beta = 1/(1+\rho), \qquad t = 0,1,2,...,T-1,T$$

In this model we assume that constraints are binding, there are no bequests and consumers are uncertain about future returns on assets. We assume that markets clear so that supply equals demand at all times[6]. This model can be easily extended to incorporate labor supply equations in the spirit of Lucas-Rapping (1969) in order to determine the impact of wages on the production process. However, the connotations of that process are outside the scope of this study.

Closed Form Solution

Assume a Cobb-Douglass production function[7] with productivity shocks z_t such that $z_t = \mu_t + \varepsilon_t$, $\varepsilon_t \sim iid(0, \sigma^2)$ and μ_t is a non-stationary component.

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[6] This assumption is reasonable assuming that automobile manufacturers engage in Just-In-Time production techniques.

[7]This parametrization is motivated by Hansen and Wright (1992).

$$F(H_t, L_t | K_t) = e^{z_t} L_t^{1-\alpha} H_t^{\alpha} \quad \textbf{[3]}$$

In a market clearing equilibrium,

$$(1-\alpha) W_t L_t = \alpha H_t P_t^H \quad \textbf{[4]}$$

Substitution for earnings from labor in the budget constraint establishes the formal link between demand for automobiles and demand for auto parts. Similarly, since markets clear, domestic automobile consumption must equal domestic production (i.e. Big 3 and transplant production) so that, $Y_t = F_t + C_t^d$ **[5]**

Solution of the automobile consumer's problem leads to the following equations derived from first order conditions (see Appendix):

$$\lambda_t P_t^c = U_C \quad \textbf{[6]}$$
$$P_t^f \lambda_t = U_F \quad \textbf{[7]}$$
$$\lambda_t = \beta E_t \ \lambda_{t+1}(1 + r_{t+1}) \quad \textbf{[8]}$$

Here λ_t is the marginal utility of wealth and ρ is the real interest rate. From **[8]** we get

$$\begin{aligned} \ln \lambda_t &= -\ln(1+\rho) + E_t[\ln \lambda_{t+1} + \ln(1 + r_{t+1})] \\ &\cong -\rho + E_t[\ln \lambda_{t+1}] + {}_t r_{t+1} \\ \Rightarrow E_t[\ln \lambda_{t+1}] &= -{}_t r_{t+1} + \rho + \ln \lambda_t \\ &= -{}_t \pi_{t+1} + \ln \lambda_t \end{aligned} \quad \textbf{[9]}$$

where ${}_t r_{t+1} = {}_t \pi_{t+1} + \rho$ is the Fisher interest rate relation, ${}_t r_{t+1}$ is expected nominal interest rate next period and ${}_t \pi_{t+1}$ is expected inflation. From **[6]** and **[7]** we get the familiar relation that the marginal rate of substitution between transplants and other automobiles is equal to the ratio of prices. Here we let P_t^c be the numeraire in US dollars so that from **[7]**

$$\lambda_t = \frac{1}{P_t^f} g({}_t A_{t+1}, A_t, r_t, W_t, L_t, F_t, P_t^f) \quad \textbf{[10]}$$

where $g({}_t A_{t+1}, A_t, r_t, W_t, L_t, F_t, P_t^f) = U_F$ for some continuous and differentiable function g. Substitute for L_t from **[4]** in **[10]** so that we now have a function of wealth, interest rate, earnings, auto parts and relative price of auto parts ($\frac{P_t^H}{P_t^f}$).

Demand Equation

The implicit function theorem and the relation for $E_t[\ln\lambda_{t+1}]$ in **[9]** suggests a general rational expectations solution as follows:

$$E_t[H_{t+1}] = {}_tH_{t+1} = g^{-1}({}_tA_{t+1}, A_t, W_t, F_t, {}_t\pi_{t+1}, H_t, \frac{P_t^H}{P_t^f}) \qquad \textbf{[11]}$$

From market clearing conditions in **[5]**, $F_t = Y_t - C_t^d$. This suggest that transplant production is negatively correlated with Big 3 production. In order to reflect price changes in parts due to exchange rate effects, substitute $P_t^H E_t$ for P_t^H in **[11]**, where E_t is yen/dollar exchange rate. Thus, after substitution we get, for some function *h*,

$$E_t[H_{t+1}] = {}_tH_{t+1} = h({}_tA_{t+1}, A_t, W_t, F_t, {}_t\pi_{t+1}, H_t, \frac{P_t^H E_t}{P_t^f}, C_t^d) \qquad \textbf{[12]}$$

A discretized differential of **[12]** on the domain of *h(.)* reduces to the following:

$$H_{t+1} = H_t + h_A \Delta A_{t+1} + h_W \Delta W_t + h_\pi \Delta\pi_{t+1} + h_F \Delta F_t + h_{C^d} \Delta C_t^d + h_q \Delta q_t + \eta_t$$

and

$$\Delta_t H_{t+1} = h_{A\,t}\Delta A_{t+1} + h_W \Delta W_t + h_{\pi\,t}\Delta\pi_{t+1} + h_F \Delta F_t + h_{C^d} \Delta C_t^d + h_q \Delta q_t + \eta_t \qquad \textbf{[13]}$$

where $q = \frac{P_t^H E_t}{P_t^f}$, $h_{(.)}$ is the partial derivative of *h* with respect to the given element of its domain, $\Delta(.)$ is the discretized incremental change (i.e. difference operator 1-*L*), and η_t is an error term. Thus, changes in transplant demand depends on changes in consumer wealth, earnings, expected inflation, auto parts, expected Big 3 production, and the relative price of imported auto parts. The following vector of trade variables was selected as instruments for the domain of *h(.)*:

$$\mathbf{Z}_t = \begin{bmatrix} b_t & a_t & c_t & f_t & p_t^J & m_t \end{bmatrix}^T$$

where b_t is seasonally adjusted Big 3 production, a_t is automobile installment credit which serves as an instrument for consumer wealth and earnings, c_t is seasonally adjusted capacity utilization in auto manufacturing industry, f_t is the transplant production that induces the derived demand for imported aut parts, p_t^J is the yen-dollar exchange rate used as an instrument for relative price and

m_t is the amount of auto parts imports. Inflation variables (e.g. consumer price indexes) were omitted since they are embedded in the yen/dollar exchange rate.

From an econometric stand point the specification in [13] suggests that the "error term" encompasses the steady state/long run values of the variables. So that [13] suggests the implementation of an econometric model which captures long run and shortrun dynamics - such as the ECM used later in this paper. Further, [13] can be expanded to include productivity and business cycle effects through the appropriate parametrization of η_t and the inclusion of lagged regressors. For instance, if η_t is nonstationary then a time trend(s) would pick up producitivity increases imbedded in μ_t from the production function. Luckett (1986) provides a review of other explanatory variables such as patterns of growth in automobile credit and other financial variables that can be included in the time *t* information set to serve as instrumental variables. Moreover, if we impose structure on the utility function (i.e. Houtakker's addilog utility), we can derive explicit closed form solutions for the demand equations. For empirical purposes we assume that agents in this model have perfect foresight and we employ a simple specification for [13] via an ECM and a parsimonious VAR to provide a dynamic system of equations.

III. EMPIRICAL RESULTS

III. 1. Data

Sample data were obtained from a variety of sources and consists of monthly observations from 1985:1-1992:12, with 1985:1-1988:12 representing the pre harmonized tariff schedule regime or the pre Free Trade in Parts Act (1988) regime. The value of imports were obtained from unpublished International Trade Commission sources. Data on Big 3 production, transplant production and the active stock of Japanese automobiles (after market sales) were obtained from the *OSAT-UMTRI Economic Database*. All other data were obtained from *Citibase Economic Database*. The aftermarket sales series is an unweighted spline of yearly data. Big 3 production and transplant production is the total car and truck production for Ford, Chrysler and GM and Honda, Toyota and Nissan automobile assembly plants in the U.S. All data used in the analyses are in levels - except the ECM analysis conducted in log levels. All production data in the forecast models were seasonally adjusted by the US Bureau of the Census X-11 procedure developed by Shiskin, et al (1967)[8].

Measurement Error

On January 1, 1989, the U.S. Department of Commerce implemented a new tariff code schedule which expanded the number of parts categories used in prior periods. This procedure was designed to make measurement of US trade data comparable and consistent with a more widely used international coding system. Moreover, customs officials were no longer allowed to include transportation and insurance costs in the value of imports. Further, the International Trade Commission defines an automotive part as a discrete product used in the assembly of components or automobiles. Thus, raw materials and other goods used in automobile manufacturing are not included in total parts import but are classified elsewhere. Therefore imports may be overstated when transportation and insurance costs are used, understated due to misclassification and expanded due to inclusion of more parts categories. The net effect of these processes on the data was the imposition of a pre tariff regime in the pre January 1, 1989 period and a post tariff regime thereafter. Further, yen/dollar volatility was relatively high in the 1985:1-1988:12 period relative to the 1989:1-1992:12 period (see Figure 5-6 in Appendix). Therefore some of this volatility may have spilled over in the valuation of trade. When the aforementioned procedures are juxtaposed against other events in the economy (i.e. increase/decrease in automobile demand) we get a nonstationary time series in the pre tariff period and a relatively stationary series in the post tariff period. The econometric approach employed later in this paper circumvent the difficulties presented by these strong regime shifts by implementing an error correction model and a Markovian or state space forecast model.

III.2 Spurrious Regressions and Pseudo-Demand Equation

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[8] Some authors have criticized use of this procedure because of its inflexibility (see Pierce (1978), Hausman and Watson (1985)). Dagum (1975) proposed the X-11 ARIMA procedure to maintain the integrity of the most recent observations whenever the series is updated. Fortunately, the US Bureau of the Census X-11 approach worked well on the production data so these pitfalls were avoided.

Since quantity data and a relative price index for imported auto parts were not available a *pseudo demand equation* is used for estimating the import content of transplant automobiles[9]:

$$m_t = \beta_0 + \beta_1 b_t + \beta_2 a_t + \beta_3 c_t + \beta_4 f_t + \beta_5 p^J_{t-1} + u_t \qquad \textbf{[14]}$$

where b_t is units of Big 3 production of cars and trucks, a_t is the level of automobile installment credit, c_t is capacity utilization in auto manufacturing industry, f_t is the amount of cars and trucks made by japanese transplants, p^J_t is the yen-dollar exchange rate and m_t is the dollar value of auto parts imports and u_t is an error term. Here we use a "sources and uses" approach to specify the pseudo demand equation in [14]. The yen/dollar exchange rate is an instrument for relative price. Similarly, automobile installment credit is a proxy for the wealth and earnings of consumers. For example, consumers decision to purchase a new automobile is based in part on their evaluation of future wealth and earnings. The results from estimating this model are shown in Table 1. Even though this model is a very plausible one, with variables derived from the theory in Section II, results are spurrious[10] so parameter estimates are not stable. For example, the intercept term is negative and the regressors b_t, c_t and f_t are stochastic. Thus, if we hold capacity utilization, transplant production and automobile installment credit constant, then imports will be

TABLE 1. *Spurrious Pseudo-Demand Model I for estimating import content of US transplants*

Variables	Coefficients	Standard Error
Intercept	-571780	193844.42
Units of Big3 Production	-0.0516	0.0449
Capacity Utilization Rate in Automotive Industry	6275.94	1827.35
Automobile Instalment Credit	2.31	0.4843
Last Period Yen-Dollar exchange rate	-317.25	403.5838
Units of Transplant Production	4.0394	0.2996

R^2=0.91, N=96

Note: Model not corrected forr heteroskedasticity hence OLS is consistent but inference tests are invalid here

9 Under "normal conditions" an inverse demand function would have price as the dependent variable and quantities as regressors. However, lack of an appropriate price index and the unavailability of quantity data precluded the estimation of a true demand function. See Diewert and Morrison (1988) for alternate specifications.

10 See Granger and Newbold (1974)

negative. This is clearly not the case. Thus, if an industry analyst employs this model to contend that the import content of Japanese transplant is on average $4,039 (see coeffficient of transplant production) then that number would be spurrious.

TABLE 2. *Spurrious Pseudo-Demand Model II for estimating import content of Japanese transplants*

Variables	Coefficients	Standard Error	t-statistic	p-value
Intercept	-1044648	1756967.70	-1.380	.1712
Units of Big3 produced autos	-0.0418	0.0568	-0.735	.4646
Auto Plants Capacity Utilization Rate	6731.50	1935.00	3.479	.0008
Auto Instalment Credit	3.0276	0.6449	4.695	.0001
Last Period Yen-Dollar rate	293.2429	537.2419	0.546	.5866
Units of transplant produced autos	3.9451	0.7991	4.937	.0001
New Car Price Index	2757.28	6104.90	0.452	.6527
Japan CPI last period	-1468.00	7766.94	-0.189	.8505

Effective sample size N=95, R^2=.90

Note: Model not corrected forr heteroskedasticity hence OLS is consistent but inference tests may be invalid here

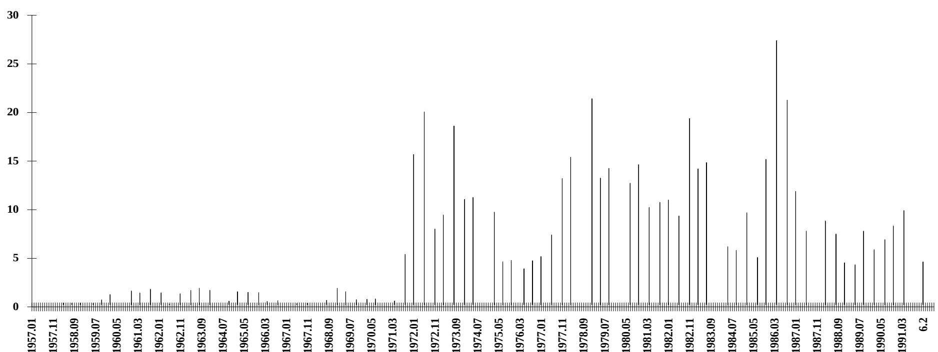
Results in Table 2 provide further evidence of the spurrious nature of the results in Table 1. Here we see that even when price variables (price indexes) are added to the pseudo-demand equation, the R^2 value does not change but the coeficient of the yen/dollar exchange rate changes sign, the estimate for import content decreases and the incongruent negative intercept term is still present. A more plausible and robust estimate of import content is shown in Table 3. Here the intercept term changes from negative to positive and the estimate of import part content is $3,345. The macroeconomic variables in Table 1 representing capcity utilization and level of automobile installment credit are proxies for new automobile production activity and new automobile

Table 3: *Stable Pseudo-Demand Model III for estimating imported parts content:*
MODEL: $USPARTIMP_t = \beta_0 + \beta_1 AFTERMKT_t + \beta_2 BIG3PROD_t + \beta_3 TRANSPROD_t + \beta_4 YEN_{t-1} + \varepsilon_t$

Variable	**Estimated Coeff**	**Standard Error**	**t-statistic for H_0:Coeff=0**	**p-value Prob > |T|**
INTERCEPT	609318	219484.51275	2.776	0.0067
Stock of active Japanese auto in US	0.006002	0.01109970	0.541	0.5900
Big3 Automobile Production	0.046727	0.06170194	0.757	0.4509
Japanese transplant production	3.345267	1.07677889	3.107	0.0025
Last period Yen-Dollar rate	-2024.333829	371.70815227	-5.446	0.0001

Effective sample size N=95 out of 96, R^2=0.8303 demand, respectively. However, there is some overlap between these variables and Big 3 and transplant production. In Table 3, these variables are substituted by the stock of active Japanese automobiles (i.e., used Japanese automobiles) in order to provide a more comprehensive picture for the use of imported parts. The results obtained from this procedure are shown in Table 3 and are more consistent with what theory tell us. The coefficients for the yen-dollar exchange rate changes dramatically. One explanation for this is volatility clustering in the yen over the sample period). In Section IV we employ a time varying specification with an interaction term to estimate the impact of policy and tariff code changes in 1989 on the auto parts trade.

Figure 3. *Yen-Dollar Volatility 1957:1-1992:6*



In this set up, one can estimate the impact of different exchange rate scenarios on imports by infusing prior beliefs in any or all of the "signals" (i.e., yen/dollar exchange rate) in Table 3. For instance, prior beliefs about the state of the economy at a future period with respect to production or incorporation of "expert" forecasts of the yen/dollar rate are possible scenarios. This is particularly important when exchange rate series are involved since the recalcitrance of these series make them difficult to forecast[11]. Figure 3 depicts the volatility clustering phenomena in the yen dollar series from 1957:1 to 1992:6. This suggests that declining (increasing) yen dollar rates are followed by decreasing (increasing) rates. Thus, one is forced to depend on an exchange rate scenario in order to forecast imports since forecasting the yen-dollar relationship will be heavily biased by the most recent rates.

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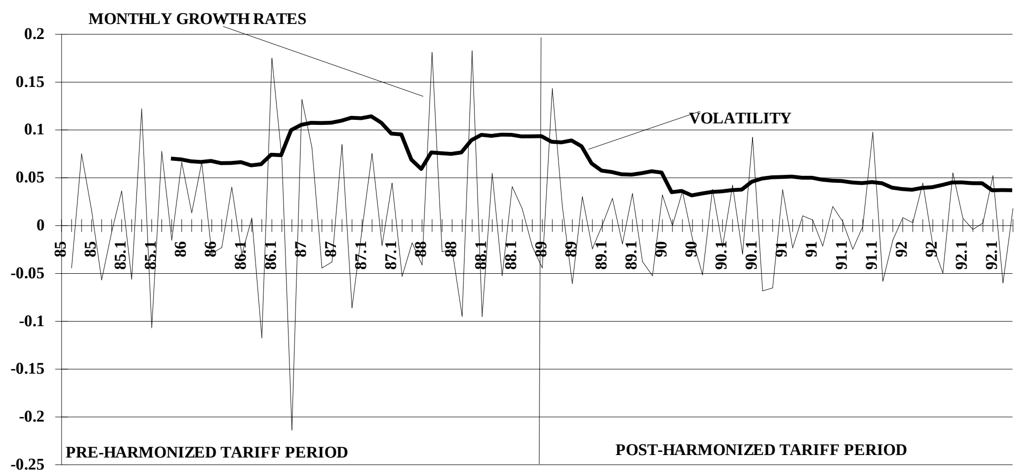
[11] See Meese and Rogoff (1983)

III.3 Error Correction Models (ECM)

In this section we show how use of an error correction model (ECM) circumvents the measurement error in trade data by focusing on the growth rate of imports. If the measurement error is consistent or systematic (in this case due to ommission), then the rate of growth of imports should be similar in pre and post tariff code regimes. Any increase in growth from one month to the next should be temporal and corrected by a disequilibrium adjustment in subsequent period(s). The short run dynamics of parts imports are depicted in Figure 3 below.

Figure 3. *Distribution of Volatility and Monthly growth Rate of US Auto Parts Imports from Japan*



The following heuristic example is designed to highlight the properties of the error correction model. Suppose that economic theory suggests the long run relationship: $Y_t = K_0 X_t^{\eta}$, where K_0 is a constant, then $\ln Y_t = \ln K_0 + \eta \ln X_t$. An econometric representation of this relationship can be specified as $y_t = \beta_0 + \beta_1 x_t + u_t$. A typical short run distributed lag parametrization could be written as

$$y_t = \beta_0 + \beta_1 x_t + \beta_2 x_{t-1} + \gamma_1 y_{t-1} + \varepsilon_t.$$

The steady state solution for the economic model requires that $y_t = y^*$ and $x_t = x^*$ for all t. After substitution of these values in the distributed lag model and equating coefficients with the short-run econometric model we obtain relationships between the β-coefficients and γ_1 (<1) such that

$$\Delta y_t = \beta_0 + \beta_1 \Delta x_t - (1-\gamma_1)(y_{t-1} - \eta x_{t-1}) + \varepsilon_t \qquad \textbf{[14]}$$

Here η is the long run elasticity and Δy_t and Δx_t are the short run disequilibrium components. The dynamic adjustment or disequilibrium term is represented by $-(1-\gamma_1)(y_{t-1}-\eta\, x_{t-1})$. Under this formulation, if *y* overshoots its equilibrium relationship with *x*, then the error is corrected in the next period so that *y* reverts to its equilibrium (see Alogoskoufis and Smith (1991), Davidson, et al (1978), Hendry and Mizon (1978), Hendry, et al (1984), Engle and Granger (1987)). Significance tests of the coefficient of this term reveals whether or not there are significant deviations away from what we would expect from economic theory[12]. Policy effects such as the Free Trade Agreement (FTA) of 1989[13], the Fair Trade in Parts Act and the Omnibus Trade and Competitiveness Act of 1988 are represented by an indicator variable. For example, the indicator variable is used to capture pre and post policy "noise". Let D_{it} be the i-th policy in effect at time t, then we write **[14]** as[14]

$$\Delta y_t = \beta_0 + \sum_{i=1}^{N} \delta_i D_{it} + \beta_1 \Delta x_t - (1-\gamma_1)(y_{t-1} - \eta x_{t-1}) + z_{t-1} + \varepsilon_t \qquad \textbf{[15]}$$

where $D_{it} = \begin{cases} 1 & \text{if i-th policy in effect at time t} \\ 0 & \text{otherwise} \end{cases}$

A version of this model was implemented (results are shown later) to test whether the implementation of a new harmonized tariff schedule[15] and the Fair Trade in Parts Act of the Omnibus Trade and Competitiveness Act of 1988 was able to capture any significant short run changes in the growth of imports and long run business-cycle effects (z_t).

The heuristic model outlined in **[15]** is robust to instrumental variable (IV) specification tests (i.e. Hausman's Test) for omitted variables. Given the paucity of time series observations available to the study, due to the short time horizon over which the harmonized trade deficit is measured, a restricted ECM may be more useful here. For instance, it may be necessary to restrict the long run

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[12]See Kiviet (1985, 1986) and Engle and Granger (1987) for more details on testing with lagged dependent variables.

[13] See Chicago Fed Letter, No 4, December, 1992. Also, the International Trade Commission implemented a harmonized tariff schedule effective January 1, 1989 which significantly reduced the volatility in import measurements.

[14] See Harvey (1990), pp 293 or Davidson, et al (1978) for further motivation of this parametrization scheme.

[15] Via this process , the International Trade Commission, effectively imposes a finer grid on trade measurement so that articles which were heretofore classified under broader categories (i.e. lower digit codes) were scrutinized and placed in the appropriate category via higher digit codes.

elasticity parameter(s) to values obtained from prior empirical studies. This stems from the fact that even though Engle and Granger (1987) provides a relatively simple two stage procedure for estimating the ECM, Stock (1987) shows that the bias in the estimators can be substantial in small samples. Thus, restricting the long run elasticities reduces the number of parameters to be estimated and improves the accuracy of the estimation procedure. This procedure was not implemented in this study.

Estimation and Implementation

In this set up the model for short run changes in imports (Δm_t) is given by:

$$\begin{aligned}\Delta m_t &= \beta_0 + \beta_1 t + \beta_2 D_t + \beta_3 (m-f)_{t-1} + \beta_4 \Delta b_t + \beta_5 \Delta f_t \\ &\quad + \beta_6 b_{t-1} + \beta_7 f_{t-1} + \beta_8 n_{t-1} + \beta_9 s_{t-1} + \beta_9 p^j{}_{t-1} + \beta_{10} a_{t-1} + \varepsilon_t\end{aligned} \qquad \textbf{[16]}$$

where t is a time trend that proxies productivity growth, D_t is a dummy variable for the Fair Trade in Parts Act of the Omnibus Trade and Competitiveness Act of 1988, $(m-f)_{t-1}$ is the temporal disequilibrium, Δb_t is change in Big3 production, Δf_t change in transplant production, lagged terms are the long run cyclical efffects on imports for Big3 production, transplant production, stock of active Japanese automobiles, yen-dolar relationship and the level of autommobile installment credit, respectively.

TABLE 4. *ECM for short run changes in US imports of Japanese Auto Parts*

Variables	Label	Coeff	t-statistic	p-value
Intercept	Intercept	-8.69	-1.621	0.1088
t	time trend*	-0.001	-0.482	0.6311
D_t	Trade Policy & Tariff Code	0.052	0.856	0.3947
$(m-f)_{t-1}$	Last period adjustment	-1.13**	-10.639	0.0001
Δb_{t-1}	Change in Big3 Prod	0.058	0.957	0.3414
Δf_{t-1}	Change in Trans Prod	0.315**	2.758	0.0072
f_{t-1}	Trans Prod last period	-0.681**	-3.937	0.0002
b_{t-1}	Big3 Prod last period	0.124**	1.817	0.0728
n_{t-1}	After Market Sales last period	1.69**	3.495	0.0008
s_{t-1}	Japan SMI last period	0.039	0.369	0.7128
p^j_{t-1}	Yen-dollar rate last period	-0.142	-0.876	0.3838
a_{t-1}	Instalment Credit last period	0.772**	1.910	0.0596

N=95, R^2=0.6341. All data is in log levels except for change and adjustment variables which are rates.
* This is a proxy for productivity growth over time
** Significant at p=0.01. See Kiviet (1985) for further details on interpreting the results.

Parameter estimates in Table 4 show that the imposition of the harmonized tariff code has no impact on the measurement of short run changes in imports. Similarly, the short run changes are independent of a time trend and the intercept at a .10 significnce level. Thus, increases in productivity growth does not have a statistically significant impact on short run changes in imports. However, the model indicates that short run changes in US auto parts imports from Japan are quite elastic to long run after market Japanese fleet in the U.S. and temporal disequilibrium adjustments in transplant production. Not surprisingly, the long run cyclical effects of consumer auto installment credit affects the level of auto parts imports. This is a proxy of demand for transplant automobiles. Interestingly, short term changes in imports are inelastic to transplant production in the long run but very elastic to short run production adjustments.

III.4 Effeciency Considerations

It should be noted that methodological considerations for efficiency are restricted by the necessity for parsimonious data transformation due to the sensitive nature of the study and the relatively small sample size. For instance, the sample data span a period of 8 years thus allowing 96 monthly observations over the pre and post harmonized tariff schedule period.Thus, relationships between variables cannot be altered by transformations which may otherwise provide efficient estimates and distort the interpretation of the model. Thus, the significance of some of the regression estimates may be questionable in the presence of autocorrelation in the error terms. This suggests utilization of robust procedures for heteroskedasticity correction and removal of autocorrelation. Fortunately, White (1980) and White and Domowitz (1982) provide procedures for consistent estimators of the covariance matrix in the presence of heteroskedasticity and autocorrelation, respectively[16]. Recently Keener, Kmenta and Weber (1991) provided a simple proof of these result. Most importantly, they provided an alternative estimator with improved small sample properties. However, these procedures were not implemented in this study.

[16] It should be noted that White (1984) also provides a taxonomy of robust procedures applicable to large sample estimtors.

IV. FORECASTS

One of the major concerns of US policy makers in the auto industry is the value of imported Japanese parts content of vehicles manufactured in the US (i.e. Japanese transplant and Big 3 production). In order to investigate whether this coefficient will change in the future (given current economic conditions in the industry), we augment the sample with a 24 month forecast, thus extenting the sample over ten years of data. Next we use the stable explanatory model developed in section III to obtain estimates of time varying import content of Japanese transplants.

State Space and Markovian Model

Univariate Case. A State Space/Markovian approach is used to develop the forecast model because of its efficacy in models with state dependent characteristics and measurement error. Consider the univariate case for imports (m_t) at time t. Let $m_t = m_t^* + v_t$ be the measurement equation, where m_t is observable but true imports (m_t^*) and measurement error[17] (v_t) are not. Suppose that true imports is AR(2) so that we have the following Markovian process

$$m_t^* = \sum_{i=1}^{2} \phi_i m_{t-i}^* + u_t \qquad \textbf{[17]}$$

In this set up, v_t and u_t are white noise measurement error and idiosyncratic error, respectively. After rearranging we get

$$\mathbf{z_t} = \mathbf{F}\mathbf{z}_{t-1} + \mathbf{G}\mathbf{e}_t \qquad \textbf{[18]}$$

where $\mathbf{z}_t = \begin{bmatrix} m_t^* \\ m_{t-1}^* \end{bmatrix}$, $\mathbf{F} = \begin{pmatrix} \phi_1 & \phi_2 \\ 1 & 0 \end{pmatrix}$, $\mathbf{G} = \begin{bmatrix} 0 & 1 \end{bmatrix}$, $\mathbf{e}_t = \begin{bmatrix} v_t \\ u_t \end{bmatrix}$

so that $\mathbf{z}_t = (\mathbf{I} - \mathbf{F}B)^{-1}\mathbf{G}\mathbf{e}_t$, B is a backshift operator, **F** is a transition matrix, **G** is an input matrix and $\mathbf{e}_t$ is a vector of error terms assumed to be white noise, **I** is a 2x2 identity matrix and $\mathbf{e}_t \sim (\mathbf{0}, \mathbf{\Sigma})$.

The Markovian representation of this univariate model is given by

[17] Including unobserved prices and customs misclassification and valuation error.

$m_t = \mathbf{H}(\mathbf{z}_t + \mathbf{e}_t) = \mathbf{H}(\mathbf{I} - \mathbf{F}B)^{-1}\mathbf{G}\mathbf{e}_t$, where $\mathbf{H} = [1 \quad 0]$, $\mathbf{z}_t$ is the selected state vector (see Appendix) and without loss of generality[18] $\hat{\mathbf{e}}_t = \left(\mathbf{H}(\mathbf{I} - \mathbf{F}B)^{-1}\mathbf{G}\right)^{-1} m_t$. The log likelihood of this process is given by:

$$\mathcal{L} = \ln L(F, G, \Sigma \big| m_t, m_{t-1}, \ldots, m_0) \propto -N/2 \ln|\Sigma| - 1/2\, tr(\Sigma^{-1}\hat{\Sigma}(F, G))$$

where

$$\hat{\Sigma}(F, G) = \tfrac{1}{N}\sum_{t=1}^{N} \hat{\mathbf{e}}_t \hat{\mathbf{e}}_t^T \xrightarrow{P} \Sigma$$

by the Lindberg-Feller Theorem (Serfling (1980), pp: 30))

For large samples the asymptotic likelihood function $\mathcal{L} \propto N/2\, ln|\mathbf{\Sigma}|1/2\, N$ and parameter (i.e., covariances and coefficients) estimates are derived from numerical MLE procedures (see Amemiya (1985), pp:137-147).

VAR Model

Multivariate Case. The following time *t* vector of interest was selected to generate forecasts of the US-Japan Auto Parts Trade.

$$\mathbf{Z}_t = [b_t \quad a_t \quad c_t \quad f_t \quad p_t^J \quad m_t]^T$$

where b_t is seasonally adjusted Big 3 production, a_t is automobile installment credit, c_t is seasonally adjusted capacity utilization in auto manufacturing industry, f_t is transplant production, p_t^J is the yen-dollar exchange rate and m_t is the amount of auto parts imports. In this set up, we assume that each element of the trade vector has measurement error so that parameter estimates are generated similar to the processes outlined earlier for the univariate case. Assume that the unobservable mean adjusted and difference stationary trade vector follows a multivariate Markovian (i.e. VAR(*p*)) process given by:

$$\mathbf{Z}_t = \mathbf{\Phi}_1 \mathbf{Z}_{t-1} + \ldots + \mathbf{\Phi}_p \mathbf{Z}_{t-p} + \xi_t$$

where

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18 Technically, we can restrict the coefficients of the input matrix G so that assumptions about the error terms or innovations are incorporated in the model. In this case, we proceed as if there was no measurement error in m_t. However, if there is, then the coefficients of the input matrix would be estimated accordingly.

$$\Phi_j = \begin{pmatrix} \phi_{11,j} & \cdots & \phi_{1M,j} \\ \vdots & \ddots & \vdots \\ \phi_{M1,j} & \cdots & \phi_{MM,j} \end{pmatrix}$$

and $\boldsymbol{\xi}_t$ is a vector of idiosyncratic error assumed to be white noise. Let the measurement equation for this model be as follows

$$\mathbf{Y}_t = \mathbf{Q}\mathbf{Z}_t + \boldsymbol{\zeta}_t \qquad \textbf{[18]}$$

Since all the variables in the trade vector have significant lag 1 partial autocorrelation, a VAR(1) specification for the Markovian process is assumed without loss of generality since each element of the vector was differenced accordingly to obtain stationartity. In order to identify the state vector, the multivariate time series $\mathbf{Y}_t$ is over fitted and the AIC criterion is applied to the smallest cannonical correlate between elements of the predictor space and the sample space. In the next step, only significant lagged variables are added to the state vector. The likelihood function for this process is given by:

$$\ln L(\Phi, \Omega | \mathbf{Y}_1, \ldots, \mathbf{Y}_N) \propto -(N/2)\ln|\Omega| - 1/2\, tr(\Omega^{-1}\hat{\Psi}(\Phi)),$$

where

$$\hat{\Psi}(\Phi) = \tfrac{1}{N}\sum_{t=1}^{N} \hat{\boldsymbol{\varepsilon}}_t \hat{\boldsymbol{\varepsilon}}_t^T \xrightarrow{P} \Omega$$

and $\hat{\boldsymbol{\varepsilon}}_t = [\hat{\xi}_t \quad \hat{\varsigma}_t]^T$ is the error matrix for the model such that $\hat{\boldsymbol{\varepsilon}}_t = [\mathbf{Q}(\mathbf{I} - \Phi B)^{-1}]^{-1}\mathbf{Y}_t$.

The estimated unrestricted VAR(1) model[19] is:

c_{t+1} =	$0.502c_t$					**[19]**
p^J_{t+1} =			$0.317p^J_t$			**[20]**
f_{t+1} =	$44.757c_t$		$-74.240p^J_t$			**[21]**
m_{t+1} =	$3.915c_t$		$-474.560p^J_t$			**[22]**
a_{t+1} =	$33.233c_t$	$+ 0.679a_t$	$-15.476p^J_t$		$-0.031f_t$	**[23]**
b_{t+1} =	$8956.959c_t$	$- 11.355a_t$	$439.413p^J_t$			**[24]**

Rearrangement of **[19] - [24]** reveals a recursive system of equations of the form

19 All variables were differenced accordingly to obtain prerequisite stationarity in the model. Only those coefficients significant at the 5% level are displayed. See Appendix for full transition matrix.

$$\begin{bmatrix} c_{t+1} \\ p^J_{t+1} \\ f_{t+1} \\ m_{t+1} \\ a_{t+1} \\ b_{t+1} \end{bmatrix} = \begin{pmatrix} \phi_{11}(L) & & & & & \\ \phi_{21}(L) & \phi_{22}(L) & & & & \\ \phi_{31}(L) & \phi_{32}(L) & \phi_{33}(L) & & & \\ \phi_{41}(L) & \phi_{42}(L) & \phi_{43}(L) & \phi_{44}(L) & & \\ \phi_{51}(L) & \phi_{52}(L) & \phi_{53}(L) & \phi_{54}(L) & \phi_{55}(L) & \\ \phi_{61}(L) & \phi_{62}(L) & \phi_{63}(L) & \phi_{64}(L) & \phi_{65}(L) & \phi_{66}(L) \end{pmatrix} \begin{bmatrix} c_t \\ p^J_t \\ f_t \\ m_t \\ a_t \\ b_t \end{bmatrix} + \begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \\ \xi_4 \\ \xi_5 \\ \xi_6 \end{bmatrix}$$

which can be written as $\mathbf{A}(L)\mathbf{Y}_{t+1} = \boldsymbol{\upsilon}_t$ where

$$\mathbf{A}(L) = \begin{bmatrix} 1-0.502L & & & & & \\ 0 & 1-0.317L & & & & \\ -44.757L & 74.240L & 1.0 & & & \\ -3.915L & 474.56L & 0 & 1.0 & & \\ -33.233L & 15.476L & 0.031L & 0 & 1-0.679L & \\ -8956.959L & -439.413L & 0 & 0 & 11.355L & 1.0 \end{bmatrix}$$

and $\boldsymbol{\upsilon}_t$ is an error vector.

Stationarity and Innovations

The condition for stationarity is seen immediately from the relation

$\mathbf{A}(L) = \mathbf{A}(1) - (1-L)\tilde{\mathbf{A}}(L)$

where $\mathbf{A}(1)$ is the long run/steady state matrix and $\tilde{\mathbf{A}}(L)$ is a matrix with lag order one less than $\mathbf{A}(L)$. So that we write

$$\mathbf{Y}_{t+1} = \mathbf{A}(1)^{-1}\tilde{\mathbf{A}}(L)\Delta\mathbf{Y}_t + \mathbf{A}(1)^{-1}\mathbf{u}_t$$

So that a necessary condition for the system to be stationary is that $\mathbf{A}(1)^{-1}$ exists. The invertibility condition for stationarity of the autoregressive element of the VAR is given by

$$|\mathbf{A}(L)| = (1-.502L)(1-.317L)(1-.679L) \neq 0$$

so that

$$\mathbf{A}(L)^{-1} = \sum_{i=1}^{3}\left\{\prod_{\substack{j=1 \\ j\neq i}}^{3}\left(\frac{\lambda_i}{\lambda_i - \lambda_j}\right)\right\}(1-\lambda_i L)^{-1}$$

where λ_i is the i-th eigenvalue of A. Thus, when $L \equiv 1$ the invertibility condition for the long run matrix is satisfied. In order to determine the innovations for each equation in the system we write the ARMA representation of the model as:

$$|\mathbf{A}(L)|\mathbf{Y}_{t+1} = \text{Adj } \mathbf{A}(L)\, \boldsymbol{\xi}_t$$
$$\Rightarrow (1-.502L)(1.-317L)(1-.679L)\mathbf{Y}_{t+1} = \text{Adj } \mathbf{A}(L)\, \boldsymbol{\xi}_t$$

where Adj[.] is the adjoint matrix generating the innovations in the trade vector. In this set up $|\mathbf{A}(L)|$ is a scalar so that each row can be used seperately to make forecasts (see Aoki and Havanner (1991)) as shown in [19] to [24].

In this six equation system US imports of Japanese auto parts is endogenous. Equation **[19]** shows that seasonally adjusted capacity utilization, automobile consumer debt burden and the yen/dollar exchange rate are significant indicators of Big 3 production. Equation **[21]** and **[22]** indicate that capacity utilization and the yen/dollar exchange rate are significant indicators of the level of transplant production and imports respectively. Further reduction of this sub-system gives the following result:

$$m_{t+1} = 0.015 f_{t+1} + 0.481 p_t^J \qquad \textbf{[25]}$$

Intuitively, **[25]** states that tha dollar value of imports in a given month is a function of the amount of transplants produced in that month and the yen/dollar relationship in the prior month.

Results from a simple transfer function model show that the direction of causality goes from imports to transplant production (i.e., $f_t \leftarrow m_t$) with significant lags at 2 and 6 months. The causality result is not surprising if one considers that auto parts are input factors of production. So that parts must be procured (i.e. imported) before production takes place. Results from this procedure are displayed in **Table 6**. A spectral analysis of imports, transplant production and the yen/dollar analysis (see power spectrum plots in Figure 13-15 in Appendix) indicate that imports and transplant production are synchronous at 2 and 4 month (i.e. approximately quarterly) cycles. However, the yen/dollar exchange rate is synchronous only at 2 month cycles.

The AR(1) representation in **[20]** captures the fact that capacity utilization in the industry is determined by a quarterly meeting of plant managers. Hence, it is fairly exogenous to the model.

Similarly, the yen/dollar relationship follows an AR(1) representation which is independent of other industry variables. It should be noted that the yen/dollar exchange rate features prominently in all the equations except **[20]**. So that it is a significant predictor and key policy target that proxies for a relative price in the model. Time series plots of the actual and forecast values for elements of the trade vector are shown in the Appendix. **Table 5** indicates that the value of the import content of Japanese transplants will increase from approximately $6Billion in 1992 to $7Billion in 1993 and $8Billion in 1994 even though the value of import content per transplant remains in the $3,400 to $3,800 range. This suggests that Japanese manufacturers will shift more production to the US as the yen continues to appreciate against the dollar. Thus, even though current trade policy may be ineffective in decreasing the import content per transplant, yen appreciation would lead to shifts in production to the US and ultimately more sourcing to US parts suppliers.

Table 5 : *Annual Distribution of Imported Parts, Transplant Production, Time Varying Import Content and Forecasts*

YEAR	IMPORTS (US dollars)	IMPORT FORECAST	TRANSPLANTS (units)	TRANSPLANT FORECAST	VALUE PER TRANSPLANT (UD dollars)	ESTIMATED VALUE OF IMPORT CONTENT	PREDICTED VALUE OF IMPORT CONTENT
1985	4,638,828	5,001,755	361,181	419,175	-6.706	(2,422,079,786)	(2,810,986,008)
1986	6,374,928	6,744,872	616,577	671,699	5.749	3,544,701,173	3,861,595,539
1987	7,784,970	8,006,703	735,713	790,132	4.387	3,227,572,931	3,466,308,338
1988	9,401,259	9,873,138	864,682	923,323	4.74	4,098,592,680	4,376,549,930
1989	11,567,276	11,573,176	1,145,221	1,181,439	4.403	5,042,408,063	5,201,875,301
1990	11,351,373	11,436,603	1,390,024	1,434,395	3.856	5,359,932,544	5,531,027,660
1991	10,802,672	11,098,612	1,548,164	1,607,056	3.411	5,280,787,404	5,481,666,822
1992	11,900,411	12,175,499	1,558,612	1,764,635	3.776	5,885,318,912	6,663,262,515
1993		13,665,295		2,080,549	3.495		7,271,520,468
1994		14,699,452		2,276,866	3.535		8,048,719,645

Model tends to over forecast transplant production and fits well in-sample for imports. The negative value for import content in 1985 is an artifact of the small sample of 12 observations for 1985 in which imports were relatively flat while transplant production increased (see time series plots in Appendix).

Table 6 : *Cross correlation function between prewhiten imported Japanese parts and transplant production*.

LAGS	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1
CROSS CORR($\rho_{\alpha\beta}$)	0.0007	0.0471	0.0383	0.0896	0.0856	-0.0383	-0.0025	0.2796**	0.0372	-0.1251	-0.0664	0.2303**	0.0251
STDERR	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
	0.0224	0.0427	0.062	-0.0161	-0.1796	-0.0524	-0.013	-0.0099	-0.0658	0.0042	-0.081	0.0048	-0.0683	-0.1431
	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098	0.1098

** Significant at p=0.05 (Critical value @ 5% significance level = $|0.2152|$)

Pre-whitening filter (s) for imports (*m*) and transplant production (*f*):

$$(1-0.1445B-0.3367B^2-0.085263B^3+0.0599B^4-0.13083B^5+0.4135B^6)m_t=\alpha_t$$
$$(1-0.1445B-0.3367B^2-0.085263B^3+0.0599B^4-0.13083B^5+0.4135B^6)f_t=\beta_t$$

Time Varying Estimates of Import Content

One of the goals of current trade policy is to reduce the import content of US made vehicles by substituting domestic content - assuming that US made parts are substitutes for imports. To estimate the impact of these policies we specify the following model:

$$USPARTIMP_t = \beta_0 + \beta_1 AFTERMKT_t + \beta_2 BIG3PROD_t + \beta_{3t} TRANSPROD_t + \beta_4 YEN_{t-1} + \varepsilon_t \qquad \textbf{[26]}$$

where the time varying parameter is $\beta_{3t} = \begin{cases} \beta_3 & 1985 \le t < 1989 \\ \beta_3 + \gamma & t \ge 1989 \end{cases}$

and β_3 is the pre policy and tariff code parts content parameter, $\beta_3 + \gamma$ is the parameter that includes policy effects, γ, that reflect the difference in import content between the two regimes.

After substitution we get:

$$\begin{aligned} USPARTIMP_t = {} & \beta_0 + \beta_1 AFTERMKT_t + \beta_2 BIG3PROD_t + \beta_3 TRANSPROD_t \\ & + \gamma(D_t * TRANSPROD) + \beta_4 YEN_{t-1} + \varepsilon_t \end{aligned} \qquad \textbf{[27]}$$

where D_t is a dummy variable (0 in pre tariff and policy regime, 1 otherwise). The interaction term in **[27]** captures the joint effect of tariff code changes, trade policy and transplant production on imports. The sample was augmented by two year (24 months) forecast and divided into 10 intervals (i.e. 12 months, 24 months, 36 months, ..., 120 months for the period 1985:1-1994:12). Time varying estimates for import content were derived from regressions for each period as shown in **Table 7**. The negative value in 1985 is an artifact of the small sample

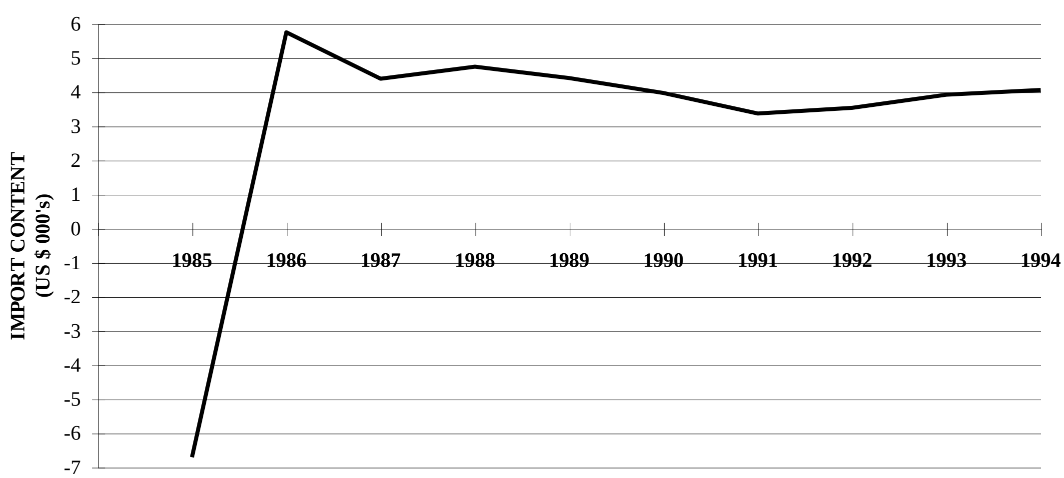
Table 7 : *Time Varying Imported Japanese Part Content of US transplant*

YEAR	$(\hat{\beta}_3)$ Pre policy and tariff code content	$(\hat{\gamma})$ Post policy and tariff code change	$(\hat{\beta}_3 + \hat{\gamma})$ IMPORT CONTENT (US $ 000's)	STANDARD DEVIATION	Regression R^2 from stable model
1985	-6.706	0	-6.706	4.037	0.38
1986	5.749	0	5.749	3.153	0.63
1987	4.387	0	4.387	1.806	0.79
1988	4.74	0	4.74	1.527	0.84
1989	4.271	0.135	4.406	1.207	0.89
1990	2.909	0.983	3.892	1.109	0.87
1991	1.605	1.763**	3.368	1.053	0.82
1992	1.513	2.020**	3.533	0.975	0.83
1993*	1.987**	1.933**	3.920	0.886	0.85
1994*	2.052**	2.007**	4.059	0.775	0.88

* Includes sample data augmented by forecasts
** Significant at 5% level

size (i.e. 12 observations) and the fact that transplant production increased at a more rapid rate than imports which were relatively flat in that year (see time series plots in Appendix). The results show that imported Japanese parts content in US transplants declined by approximately \$334.00 (i.e between 1988 and 1989) after the Free Trade in Parts Act and the harmonized tariff schedule in 1989. It declined by \$848.00 (i.e. between 1988 and 1990) or by \$514.00 one year after the schedule was in place. The prognosis for the next few years is that import content will increase from \$3,533.00 per transplant in 1992 to \$3,920.00 in 1993and \$4,059.00 in 1994. A time series plot of the time varying import content is depicted in Figure 4. It shows that the value of imported parts content decreased significantly (see Table 7) in 1991 in response to the

FIGURE 4 : *Distribution of Imported Japanese Parts Content 1985-1994*



tariff and policy initiatives of the authorities but increased thereafter. So that even though a lot of attention has been given to the issue of import content, indications are that current trade policies were effective in the short run but ineffective in inducing a substantial decrease in import content in the long run. This, despite the fact that more production will be shifted to the US.

IV. CONCLUSION

This paper presented a simple intertemporal rational expectations model which was used to select a vector of variables encompassing elements of international finance and sectoral trade policies in U.S.-Japan Bilateral Auto Parts trade. Econometric specifications were selected to capture many of the salient characteristics of modelling and forecasting bilateral US-Japan auto parts trade (within the frameowrk of trade and tariff policies) in the presence of measurement error and switching regimes. Additional approaches that focus on inferential analysis in the presence of measurement error were ommitted due to time and space (see Guilkey and Schmidt (1973) and Doran and Griffiths (1983)). Nonetheless, the techniques implememnted in the paper are robust enough to include inference. This study demonstrated that measurement error and swithching regimes in import data could lead to spurrious regressions if an appropriate subset of trade variables are not properly chosen. We show how to select a stable and parsiminous model which was later modified to provide consistent estimates of the import content of Japanese transplants. A VAR(1)/Markovian model derived from a State Space approach was used to generate forecast of the trade variables used in the stable-parsimonious model. These values were then used to augment the sample in order to provide *ex-ante* estimates of time varying value of import content over a two year horizon. Our results predict that Japanese manufacturers would shift more production of automobiles to the US in response to yen appreciation. Therefore, even though trade policies were shown to be impotent in affecting a substantial decrease of import content in the long run, the increase in transplant production may lead to an increase in the volume of auto parts sourcing to domestic suppliers. In that scenario, domestic policy fo increased domestic sourcing attains its goals indirectly. Further research on factors determining Japanese import of non-transplant US made auto parts, the import content of Big 3 after market fleet and an analysis of the domestic parts content of US made automobiles, is needed to provide a comprehensive analysis of the auto parts trade. The work by Backus, Kehoe and Kehoe (1991, 1992) provides a basis for these analyses.

APPENDIX

DEMAND FOR TRANSPLANT AUTOS

Let L(.) be the Lagrangean so that

$$L(.) = E_t\left[\sum_{t=0}^{T}\beta^t[U(C_t,F_t) - \lambda_t(C_t + P_tF_t + A_{t+1} - (1+r_t)A_t - W_tL_t)\right]$$

$$\frac{\partial L}{\partial C_t} = U_c - \lambda_t P_t^c = 0$$

$$\frac{\partial L}{\partial F_t} = U_F - \lambda_t P_t^f = 0$$

$$\frac{\partial L}{\partial A_{t+1}} = -\beta^t\lambda_t + E_t[\beta^{t+1}\lambda_{t+1}] = 0$$

See Sargent (1987) for further details on solution to finite-lived-discrete-time intertemporal models.

SELECTING THE STATE VECTOR

The state vector is determined via a canonical correlation and Akaike Informmation Criterion as follows. Let $S_N = \{m_N, m_{N-1}, ..., m_1\}$ be the sample space of N observations and $P_N = \{m_N, m_{N-1}, ..., m_1, m_{N+1|N}, m_{N+2|N}, ..., m_{N+k|N}\}$ be the augmented k-step ahead predictor space. Let

$$\mathbf{X}^{(1)} = \begin{bmatrix} m_1 & \dots & m_N \end{bmatrix}^T,\ \mathbf{X}^{(2)} = \begin{bmatrix} m_{N+1|N} & \cdots & m_{N+k|N} \end{bmatrix}^T,$$

$$\mathbf{S} = [(\mathbf{X}^{(1)} - \overline{\mathbf{X}}^{(1)})(\mathbf{X}^{(2)} - \overline{\mathbf{X}}^{(2)})^T] = \begin{pmatrix} \mathbf{S}_{11} & \vdots & \mathbf{S}_{12} \\ \cdots & \vdots & \cdots \\ \mathbf{S}_{21} & \vdots & \mathbf{S}_{22} \end{pmatrix}$$

be the (sample) covariance matrix between the sample space and the k-step ahead subset of the predictor space as shown. The bar notation signifies a vector of means. The cannonical correlates are the roots (eigenvalues) of the following characteristic equation $f(\lambda) = \left|\mathbf{S}_{11}^{-1/2}\mathbf{S}_{12}\mathbf{S}_{22}^{--1}\mathbf{S}_{21}\mathbf{S}_{11}^{-1/2} - \lambda\mathbf{I}\right| = 0$. The AIC (Akaike(1976)) criterion is derived from the statistic $AIC = -N\,ln(1-\lambda_{min}^2) - 2[N(k+1) - q + 1]$, where q is the dimension of the current subset of the predictor space in order (i.e. $q \le N + k$). If the AIC statistic is greater than zero then the q-th element of the predictor space is added to the state vector or dropped otherwise[20]. Since the sample space is a sub-space of the predictor space, elements of the predictor space are

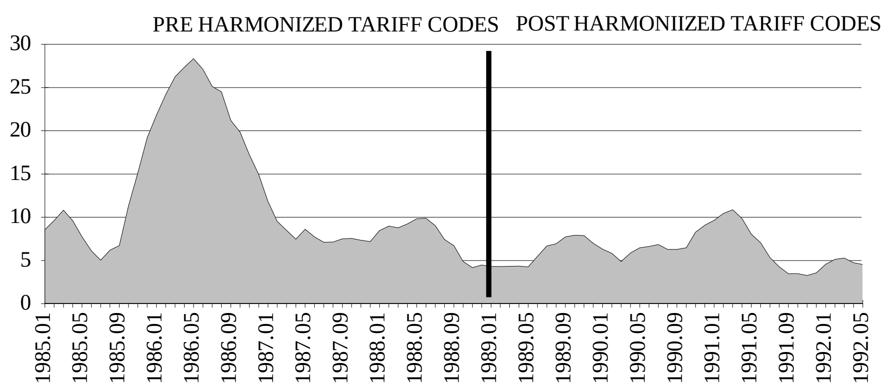
[20] Bartlett's (1941) test for the smallest eigenvalue also produces similar results.

included in the state vector only if the smallest cannonical correlation is statistically greater than zero.

RESULTS FROM PROCEDURES

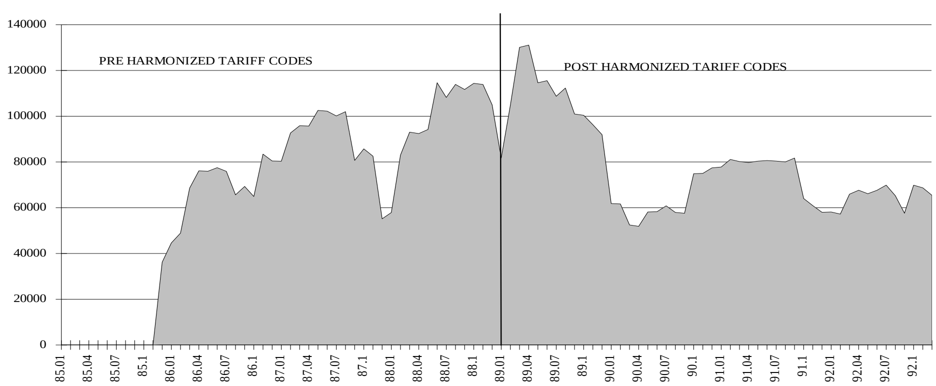
The relatively high yen-dollar volatility over the pre-harmonization period contributed to the volatility in the value of imports. Thus discarding pre-harmonization data throws away valid information.

Figure 5. *Yen-Dollar Volatility in pre and post Trade Policy & harmonization period*



Source: Compiled from *International Financial Statistics, International Monetary Fund*

Figure 6. *Volatility of value of US imports of Japanese Auto parts*



Data Source: *International Trade Commission*

The volatility plot for imports suggests that tariff code harmonization reduced the volatility by approximately 50%. However, yen-dollar exchange also plays an important part.

Figure 7 : Units of Big 3 Production

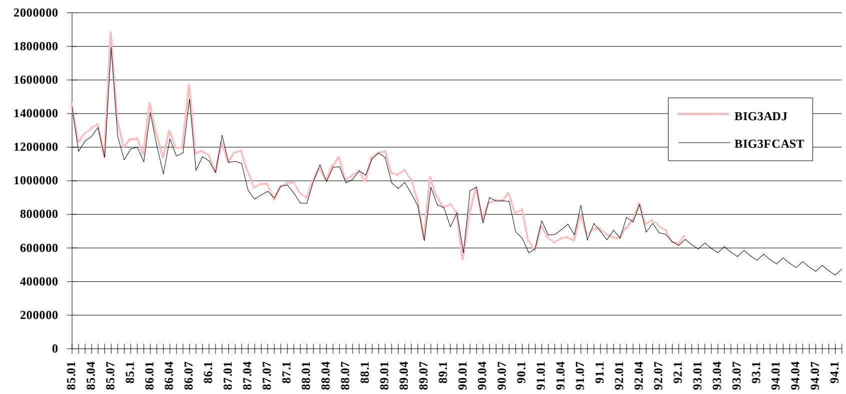


Figure 8 : US Imports of Japanese Auto Parts (US dollars)

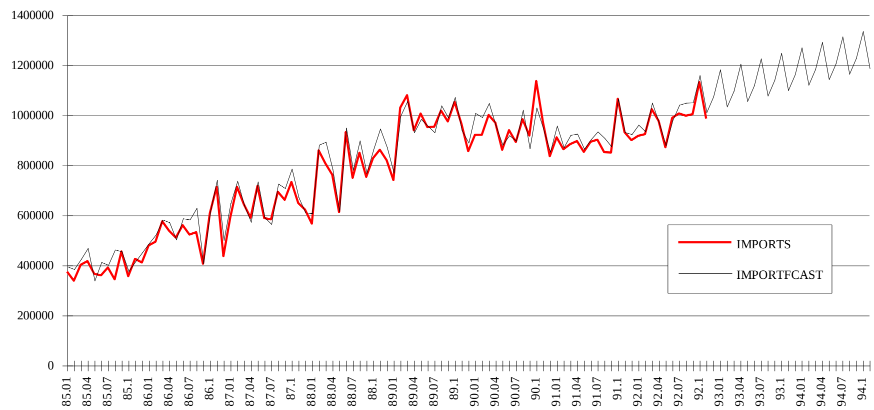


Figure 9 : Units of Japanese Transplant Production

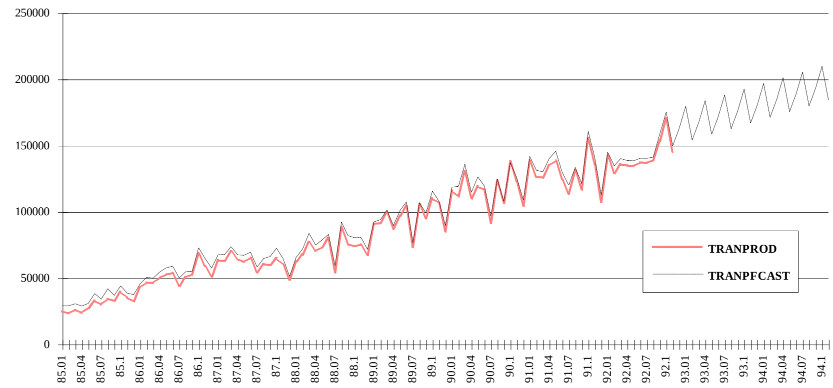


Figure 10 : Seasonally adjusted capacity utilization (percent)

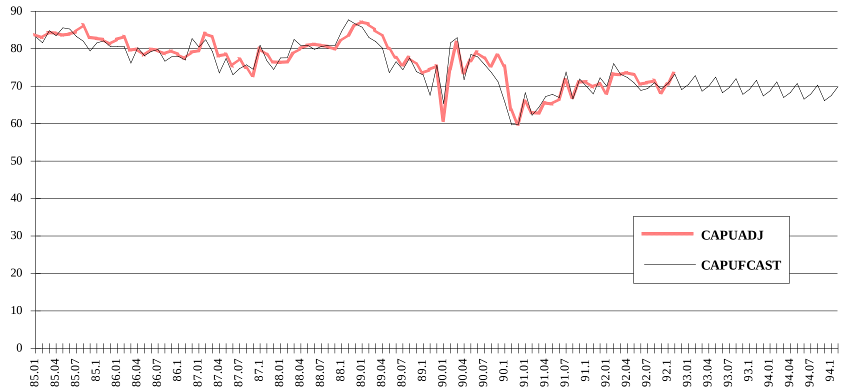


Figure 11 : Consumer Automobile Installment Credit (in Millions of Dollars)

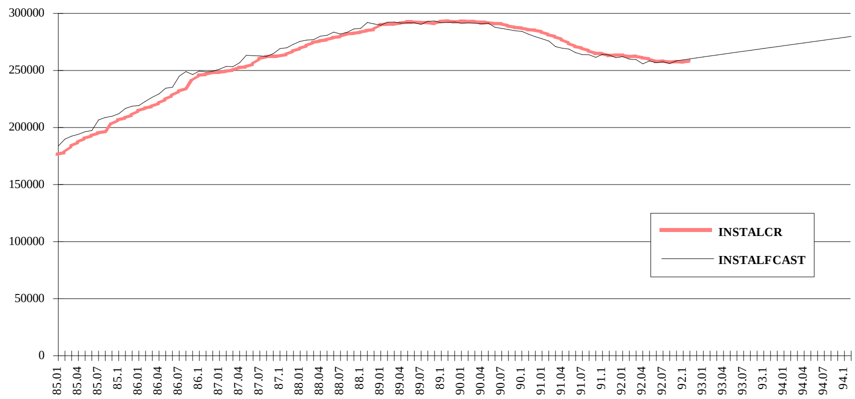


Figure 12: Yen/Dollar Exchange Rate

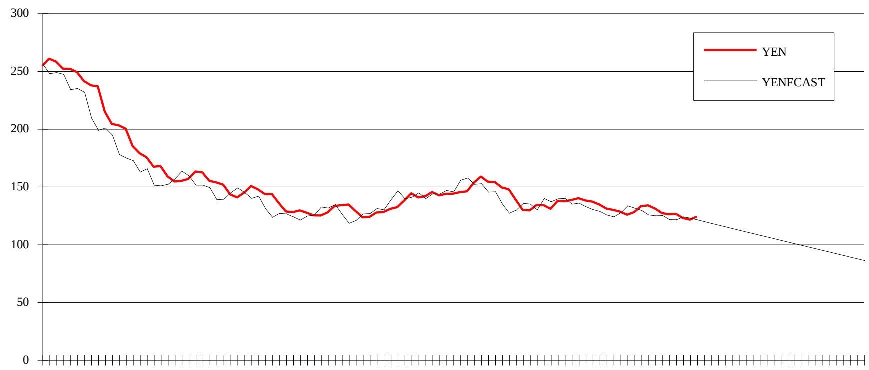


Figure 13 :*Power Spectrum of Imported Japanese Parts and Yen/Dollar Exchange Rate*

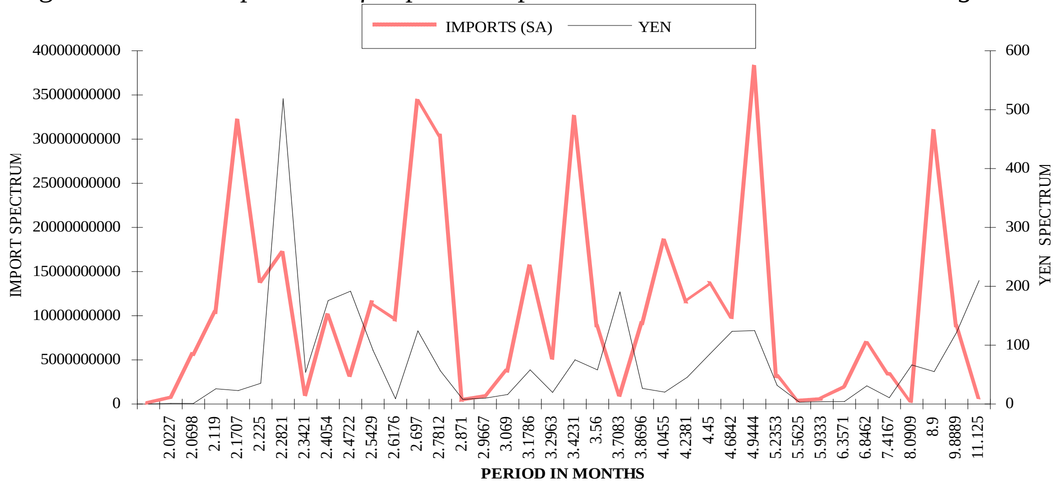


Figure 14 : *Power Spectrum of Imported Japanese Parts and Transplant Production*

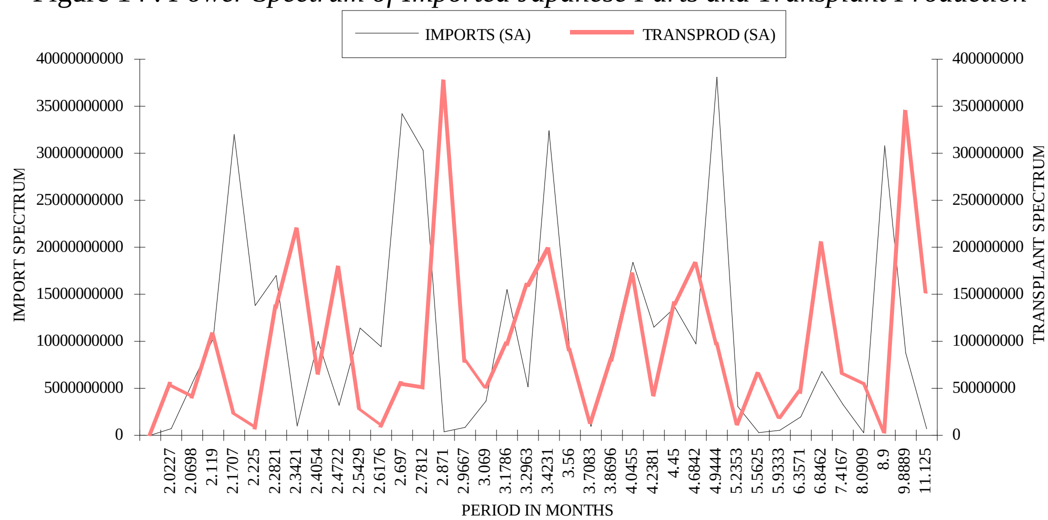
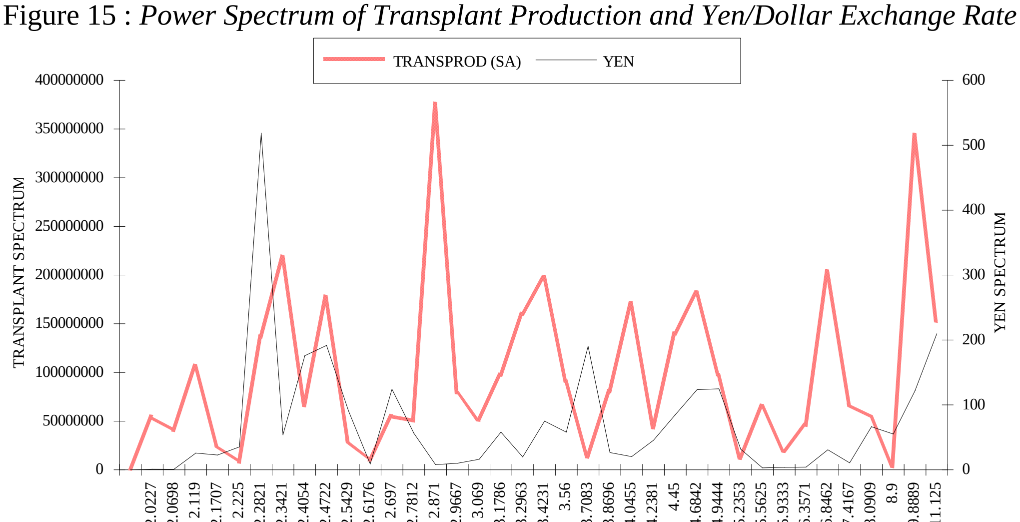


Figure 15 : *Power Spectrum of Transplant Production and Yen/Dollar Exchange Rate*



DATA APPENDIX

Data source is enclosed in brackets. Aftermarket sales is not shown since monthly data for this variable was created by a spline of annual data reported by OSAT-UMTRI.

YEAR.MM=Year and Month; BIG3ADJ=Seasonally Adjusted Big 3 Production Units (OSAT-UMTRI);
CAPUADJ=Seasonally Adjusted Percent Capacity Utilization in Automotive Industry (Citibase);
INSTALCR=Consumer Automobile Installment Credit from Commercial Banks ($M, Citibase);
YEN=Yen/Dollar Exchange Rate (Citibase); TRANSPROD=Transplant Production Units (OSAT-UMTRI);
IMPORTS=US Import of Japanese Made Auto Parts (US Dollars, ITC);
EXPORTS=US Exports of Auto Parts to Japan (US Dollars, ITC).

YEAR.MM	BIG3ADJ	CAPUADJ	INSTALCR	YEN	TRANPROD	IMPORTS	EXPORTS
85.01	1461439	83.61	176049	254.18	24692	374416	12827
85.02	1228792	82.73	177696	260.48	23220	338121	14209
85.03	1272099	84.19	183014	257.92	26089	401776	16596
85.04	1307235	83.99	186732	251.84	23674	416486	15923
85.05	1333883	83.48	190026	251.73	27407	365512	15821
85.06	1140659	83.8	192359	248.84	32714	359747	17696
85.07	1877920	84.27	194744	241.14	29784	391050	18398
85.08	1358719	86.08	196211	237.46	34217	343715	18769
85.09	1199857	82.84	202150	236.53	32722	455232	17436
85.1	1240141	82.59	205776	214.68	39361	356004	20317
85.11	1248476	82.3	207868	204.07	35002	425709	19761
85.12	1153644	81.02	210238	202.79	32299	411060	15540
86.01	1454129	82.3	213848	199.89	42498	479035	21877
86.02	1280316	82.97	216517	184.85	46451	493937	17040
86.03	1137287	79.45	217943	178.69	46269	575486	12346
86.04	1288299	79.71	220821	175.09	50098	538067	24210
86.05	1195161	78.01	224133	167.03	52565	510350	16749
86.06	1194688	79.68	227284	167.54	53561	559932	13264
86.07	1567233	79.41	231304	158.61	44068	522463	15631
86.08	1159210	78.53	233355	154.18	50445	532068	24216
86.09	1173836	79.35	240268	154.73	52461	406041	24822
86.1	1149594	78.32	245556	156.47	68315	607597	14997
86.11	1051586	77.18	245854	162.85	58718	713569	23226
86.12	1221611	78.94	247772	162.05	51128	436383	16496
87.01	1107687	79.29	247970	154.83	63155	591045	14417
87.02	1162673	83.85	248536	153.41	62707	712904	17586
87.03	1174556	83	249845	151.43	70074	643812	23951
87.04	1046602	77.89	251812	143	64546	589810	19983
87.05	955886	78.27	252511	140.48	62018	716806	17018
87.06	976341.1	75.27	254949	144.55	65330	588290	25653
87.07	976025	76.99	259641	150.29	54209	583222	20277
87.08	886155.6	74.71	261417	147.33	60504	693803	25009
87.09	957748.4	72.62	261841	143.29	59743	661464	24175
87.1	982210.7	79.9	261887	143.32	64872	732843	23289
87.11	987275.3	78.25	263341	135.4	60014	648628	26190
87.12	926258.3	76.3	266295	128.24	48541	622343	23714
88.01	893765.2	76.21	268466	127.69	62558	566321	25073
88.01	994451.5	76.34	270852	129.17	67521	859019	33877
88.03	1066653	78.48	273687	127.11	76863	806813	31719
88.04	1001375	79.85	275099	124.9	70460	761846	33113
88.05	1084480	80.71	276414	124.79	73235	612449	34984

88.06	1131783	81.05	278272	127.47	79988	932676	39350
88.07	1002482	80.71	279326	133.02	54116	749439	32543
88.08	1024018	80.46	281630	133.77	88016	850028	38177
88.09	1053678	79.76	281814	134.32	75549	753460	39942
88.1	992890.5	81.91	282798	128.68	73951	827755	40743
88.11	1132466	83.4	284407	123.2	75091	861727	42020
88.12	1162821	85.82	285364	123.61	67334	819726	37150
89.01	1170491	86.97	289540	127.36	90925	740193	39111
89.02	1047821	86.48	290111	127.74	91204	1029548	38848
89.03	1030205	84.86	289928	130.55	99403	1079533	49338
89.04	1060567	83.26	290872	132.04	87196	939034	40294
89.05	1005949	79.86	291926	137.86	96782	1006562	42616
89.06	883581.5	77.46	291874	143.98	104440	951996	39500
89.07	649913.5	75.44	291347	140.42	72941	953473	39924
89.08	1015257	77.48	291629	141.49	105647	1018124	61536
89.09	900627.9	75.8	290587	145.07	95028	974619	40755
89.1	837401.3	73.32	292497	142.21	109883	1052691	53745
89.11	855943.5	74.17	292952	143.53	106698	965608	50481
89.12	812629.8	75.21	292002	143.69	85074	855895	62802
90.01	529039.4	60.63	292338	144.98	115986	921161	52729
90.02	814291.3	74.45	292328	145.69	111331	921488	54404
90.03	948683.4	81.39	292189	153.31	130391	1000786	57815
90.04	767819.5	73.39	291363	158.46	109814	969500	49097
90.05	863320.9	76.61	291349	154.04	119017	861241	66089
90.06	880610.5	78.91	290712	153.7	116602	939636	50989
90.07	880288.5	77.25	290665	149.04	91337	892533	61058
90.08	920270.6	75.23	288763	147.46	123548	983500	56887
90.09	802078.9	78.08	287197	138.44	106489	918553	72958
90.1	826165.6	75.2	286667	129.59	138079	1136198	76108
90.11	637334.8	63.57	285488	129.22	122960	971053	59590
90.12	582331.2	59.59	284993	133.89	104470	835724	67094
91.01	721681.9	65.77	283318	133.7	138272	911109	69629
91.02	662381.9	62.76	281120	130.54	126724	863467	70770
91.03	626660.5	62.64	279277	137.39	125800	884101	72396
91.04	651566.5	65.32	276963	137.11	134821	896278	60727
91.05	663511	65.05	273389	138.22	138462	853136	62083
91.06	641627.8	66.34	270789	139.75	124212	893362	63938
91.07	792830.9	71.44	268897	137.83	113552	901826	61684
91.08	672933.1	66.79	266620	136.82	131462	851964	65657
91.09	708027.7	70.85	264621	134.3	116451	850516	74628
91.1	717909.7	71.06	264420	130.77	155534	1065196	82305
91.11	679422	69.57	262383	129.63	135711	931770	71731
91.12	659983.9	70.46	263003	128.04	107163	899947	79097
92.01	654969.9	67.93	263134	125.46	142315	917306	64572
92.02	712544.2	73	261659	127.7	128963	924016	75593
92.03	756164.5	72.86	262125	132.86	135518	1023603	81566
92.04	859424.6	73.51	260376	133.54	134897	976758	59073
92.05	734906.4	72.95	259834	130.77	134538	871196	65263
92.06	765063.2	70.39	257339	126.84	137296	989042	68806
92.07	731764.4	70.8	257743	125.88	136764	1006816	69318
92.08	700690.1	71.26	256944	126.23	138813	997551	101147
92.09	637821.7	68.07	257384	122.6	153618	1003832	90649
92.1	621332.7	70.3	256846	121.17	170656	1131946	85118
92.11	665612.7	73.14	257740	123.88	145234	986276	83115
92.12	633635.7	69.55799	292810.6	112.614	144633.6	1072069	81180

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